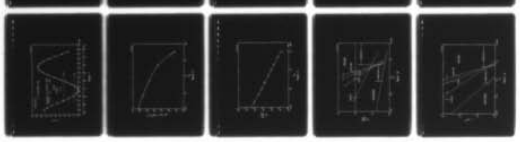
AD-A057 348 IOWA UNIV IOWA CITY DEPT OF PHYSICS AND ASTRONOMY F/G 3/2
ON THE PLASMA SHEET IN JUPITER'S DAWN MAGNETODISC.(U)
JUN 78 J A VAN ALLEN N00014-76-C-0016
UNCLASSIFIED U. OF IOWA-78-29 NL

| OF |
AD
A057348



END
DATE
FILMED
9-78
DDC

LEVEL II

U. of Iowa 78-29

(11)

Department of Physics and Astronomy

THE UNIVERSITY OF IOWA

Iowa City, Iowa 52242

78 08 10 028

LEVEL II

U. of Iowa 78-29

11

On the Plasma Sheet in Jupiter's Dawn Magnetodisc

by

J. A. VAN ALLEN

Department of Physics and Astronomy
The University of Iowa
Iowa City, Iowa 52242

For: Chapman Conference on
Jovian Magnetosphere -- Satellite Interactions

27-29 June 1978

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER (14) U. of Iowa-78-29	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER --
4. TITLE (and Subtitle) (6) On the Plasma Sheet in Jupiter's Dawn Magnetodisc,		5. TYPE OF REPORT & PERIOD COVERED Progress, June 1978
		6. PERFORMING ORG. REPORT NUMBER --
7. AUTHOR(s) (10) J. A. Van Allen		8. CONTRACT OR GRANT NUMBER(s) (15) N00014-76-C-0016
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS -- (9) Progress rept.,
11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research, Electronics Program Office, Arlington, Virginia 22217		12. REPORT DATE (11) June 1978
		13. NUMBER OF PAGES 29
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) (12) 31p.		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE --

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

--

18. SUPPLEMENTARY NOTES

Chapman Conference on Jovian Magnetosphere -- Satellite Interactions
27-29 June 1978

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Jupiter
Magnetosphere
Plasma Sheet

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

See reverse side.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

188 460 LB

ABSTRACT

Stimulated by the recent work of Walker, Kivelson, and
was made
Schardt, I have made a detailed re-examination of the University of Iowa data on energetic electrons during a Pioneer 10 encounter with the plasma sheet in Jupiter's dawn magnetodisc at about 51 R_J — sub J (Jupiter equatorial radii) on 6-7 December 1973. I have also
also, was the
repeated, in a quasi-independent manner, the Walker et al. analysis of data on energetic protons for this encounter.

On the whole, it appears reasonable to accept the conclusion of Walker et al. that very hot plasma (characteristic particle energy ~ 0.1 MeV) is an important and probably dominant contributor
about
to the pressure of the plasma confined by the magnetic field in Jupiter's dawn magnetodisc. The pressure of energetic protons is greater than that of energetic electrons by a factor of the order of ten. It is plausible that charge neutrality exists for the energetic particles at a number density $n \sim 3 \times 10^{-3}$ cm^{-3}. The
of about .003/cu.cm.
additional presence of cool plasma is not excluded by present knowledge but an upper limit on its density can be placed on the basis of the relative un-importance of centrifugal pressure.

I. INTRODUCTION

One of the most striking features of Pioneer 10's outbound traversal of the dawn magnetosphere of Jupiter in early December 1973 was the periodic, ten-hour variation of the intensities of energetic particles. These observations are illustrated by the data for electrons in Figure 1 [Van Allen, 1976]. In faithful correlation with the maxima of energetic particle intensities there were minima in magnetic field strength $|\vec{B}|$ [Smith et al., 1974]. Examples are given in Figure 2 [Van Allen et al., 1974].

Recently, Walker et al. [1978] have provided a fresh stimulus to discussion of this correlation by making quantitative estimates of the volume density of kinetic energy of charged particles $\mathcal{E}$ (i.e., particle pressure) in the implied plasma sheet (current sheet) and a comparison of this quantity with $\Delta B^2/8\pi$, the difference in magnetic pressure outside and inside the plasma sheet. Their principal conclusion is that the quantity $\beta \equiv \mathcal{E}/(\Delta B^2/8\pi)$ may be of the order of unity for protons having energies above a characteristic energy E^* (to be defined more exactly in a later section) of the order of 0.1 MeV.

In this paper, I do a similar study for energetic electrons as observed by the University of Iowa instrument on Pioneer 10 and review the work of Walker et al. for one example of a plasma sheet encounter on 6-7 December 1973.

II. RELEVANT OBSERVATIONAL DATA

In Figure 3 is shown a plot of B^2 as a function of time for the case in question (data courtesy of E. J. Smith). The dashed line is adopted as the baseline for B^2 just outside of the current sheet. In the lower panel of Figure 4 is shown $\Delta B^2/8\pi$ as a function of time as reckoned from this baseline. The upper panel shows the spin-averaged intensity (in arbitrary units) of electrons $E_e > 0.060$ MeV, the lowest energy threshold of our detector system.

The two curves are strikingly similar in form, even to relatively fine scale detail. A similar remark has been made by Walker et al. in examining the comparison of the intensity-time curve for protons $0.54 < E_p < 1.85$ MeV [Simpson et al., 1974] with that of $\Delta B^2/8\pi$ (Figure 5). In Figure 6, intensity-time profiles for electrons in four different energy ranges are shown. The curves have been normalized approximately near their peaks in order to exhibit their comparative shapes. (Background has not been subtracted.) The data are 1.79-minute spin-averaged counting rates of our detectors in order of increasing energy thresholds G, B, A, and C.

The statistical uncertainty of each 1.79-minute average is 23 $R^{-\frac{1}{2}}$ percent for G and 32 $R^{-\frac{1}{2}}$ percent for B, A, and C, where R is the rate in counts s^{-1}.

The geometric nature of the plasma sheet penetration by Pioneer 10 on 6-7 December 1973 is indicated by Figure 7. This diagram gives the calculated perpendicular distance Z_D of the spacecraft from the magnetic equatorial plane as a function of time for a centered dipole as specified. The observed minimum value of $|\vec{B}|$ ($\sim 2\ \gamma$) is almost certainly very close to the center of the current sheet as predicted by this dipolar model, though the observed time of occurrence of the minimum (2348 ERT) is about 40 minutes later than the predicted time (2309 ERT) (ERT = Earth Received Time of the telemetry signal). This time lag is well known [Van Allen et al., 1974; Northrop et al., 1974; Fillius and McIlwain, 1974].

III. ANALYSIS OF ELECTRON DATA

For the purpose of a preliminary study I have analyzed our electron data in the interval 2324-2348 ERT of 6 December near the peaks of the counting rate curves. The absolute integral omnidirectional intensity spectrum of electrons (Figure 8) is based on a full and accurate reduction of the counting rate data. This curve of $J_o(>E_e)$ was differentiated numerically to produce a

table of dJ/dE vs E (dropping subscripts). The corresponding differential number density spectrum is

$$\frac{dn}{dE} = \frac{1}{v} \frac{dJ}{dE} ,$$

where v is the particle speed at kinetic energy E. A plot of $E \frac{dn}{dE}$ is given in Figure 9. For $E < 8$ MeV

$$E \frac{dn}{dE} = 1.199 \times 10^{-6} E^{-1.177}$$

with E in MeV and n in cm^{-3}. (These units are used throughout, except for energy density.)

The total energy density $\mathcal{E}$ of energetic electrons above an energy E^*

$$\mathcal{E} = \int_{E^*}^{\infty} E \frac{dn}{dE} \text{ AE}$$

$$\mathcal{E} = 1.085 \times 10^{-11} (E^*)^{-0.177} \text{ erg cm}^{-3} .$$

Also

$$n = \int_{E^*}^{\infty} \frac{dn}{dE} \text{ dE}$$

$$n = 1.019 \times 10^{-6} (E^*)^{-1.177} \text{ cm}^{-3} .$$

The value of $\Delta B^2/8\pi$ is 6×10^{-10} erg cm^{-3} at its peak (Figure 4).

The value of $\beta \equiv \mathcal{E}/(\Delta B^2/8\pi)$ is plotted vs E^* in the lower part of Figure 10 and n vs E^* in the lower part of Figure 11.

IV. ANALYSIS OF PROTON DATA

From Figure 5 and Simpson et al. [1974] for the appropriate geometrical factor ($g = 0.49\ cm^2\ sr$),

$$J = 2.82 \times 10^4\ (cm^2\ s)^{-1}$$

for $0.54 < E_p < 1.85$ MeV at the maximum point of the proton intensity curve.

Trainor et al. [1974] give

$$J = 1.1 \times 10^3\ (cm^2\ s)^{-1}$$

for the overlapping energy range $1.2 < E_p < 2.15$ MeV. If one fits a power law differential spectrum $dJ/dE = k\ E^{-\gamma}$ to these two independent values (a somewhat risky procedure), $\gamma = 5.0$. There seem to be no published values of spectral indices for protons in this segment of Pioneer 10 data, though general remarks in the literature [McDonald and Trainor, 1976] suggest a value of $\gamma \sim 4$. Nor have any intensities for $E_p < 0.54$ MeV been reported. I have, therefore, undertaken to reproduce the calculations of Walker et al. for the four cases $\gamma = 2, 3, 4,$ and 5. The results

are as following, using $J = 2.82 \times 10^{4}\ (\mathrm{cm}^2\ \mathrm{s})^{-1}$ for $0.54 < E_p < 1.85$ MeV as the only tie point to observation.

For $\gamma = 2$

$$\frac{dJ}{dE} = 2.15 \times 10^{4}\ E^{-2}$$

$$\frac{dn}{dE} = 1.553 \times 10^{-5}\ E^{-2.5}$$

$$\varepsilon = 4.98 \times 10^{-11} (E^{*})^{-0.5}$$

$$n = 1.035 \times 10^{-5}\ (E^{*})^{-1.5}$$

For $\gamma = 3$

$$\frac{dJ}{dE} = 1.798 \times 10^{4}\ E^{-3}$$

$$\frac{dn}{dE} = 1.299 \times 10^{-5}\ E^{-3.5}$$

$$\varepsilon = 1.387 \times 10^{-11}\ (E^{*})^{-1.5}$$

$$n = 5.196 \times 10^{-6}\ (E^{*})^{-2.5}$$

For $\gamma = 4$

$$\frac{dJ}{dE} = 1.366 \times 10^{4} E^{-4}$$

$$\frac{dn}{dE} = 9.87 \times 10^{-6} E^{-4.5}$$

$$\varepsilon = 6.33 \times 10^{-12} (E^{*})^{-2.5}$$

$$n = 2.82 \times 10^{-6} (E^{*})^{-3.5}$$

For $\gamma = 5$

$$\frac{dJ}{dE} = 9.66 \times 10^{3} E^{-5}$$

$$\frac{dn}{dE} = 6.98 \times 10^{-6} E^{-5.5}$$

$$\varepsilon = 3.194 \times 10^{-12} (E^{*})^{-3.5}$$

$$n = 1.551 \times 10^{-6} (E^{*})^{-4.5}$$

In the upper part of Figure 10 is shown the value of β for protons as a function of E^{*} and in the upper part of Figure 11 is shown the value of n as a function of E^{*}.

V. GYRORADII OF ELECTRONS AND PROTONS

For later reference, tables of magnetic rigidity for electrons and protons are included here in convenient units.

Electrons

E_e	$B \cdot \rho$
0.05	0.01082 $\gamma \cdot R_J$
0.10	0.01565
0.50	0.04077
1.0	0.06645
5.0	0.2564
10.0	0.4907
20.0	0.9584

Protons

E_p	$B \cdot \rho$
0.1 MeV	0.640 $\gamma \cdot R_J$
0.5	1.432
1.0	2.025
10.0	6.420

For example, the gyroradius ρ of a 1 MeV proton in a 5 γ field with $\vec{v}$ perpendicular to $\vec{B}$ is 0.4 R_J.

VI. POSSIBILITY OF HEAVY IONS

According to Trainor et al. [1974], the intensity ratio of helium ions to protons at equal values of energy per nucleon in the vicinity of 4 MeV/nucleon is $\sim 2 \times 10^{-3}$ at about 50 R_J. There is no observational knowledge of the intensity of energetic ions of greater mass. A singly charged Na ion having a specific kinetic energy of 0.1 MeV/nucleon or a total kinetic energy of 2.3 MeV has a magnetic rigidity of 14.7 $\gamma \cdot R_J$ or a gyroradius of 3 R_J

in a 5γ field. Hence it appears quite unlikely that such ions would be confined to the plasma sheet; but there is no evident basis for excluding the possibility of heavy ions of substantially lesser energy, much below the level of present observational knowledge.

VII. ANGULAR DISTRIBUTION OF ELECTRONS

We have made a detailed study of the pitch angle distributions of electrons $E_e > 0.060$, 0.55, and 5 MeV within the plasma sheet of 6-7 December with a time resolution of seven minutes. The typical coverage of pitch angle α is from 20° to 160°. At no time during the plasma sheet encounter is there a significant departure from isotropy. The best statistical accuracy is obtained for $E_e > 0.060$ MeV (detector G); in this case near the center of the plasma sheet a 10% anisotropy would be detected clearly.

VIII. ANGULAR DISTRIBUTION OF PROTONS

There appear to be no published data on the angular distribution of protons for the case under study but such data may be available in either the GSFC or the University of Chicago files.

IX. DISCUSSION

A. Energy Densities

By Figure 10, it is seen that $\beta = 0.03$ for the observed part of the electron spectrum and $\beta = 0.05$ for the observed part of the proton spectrum. These values are reliable lower limits. The value of β for electrons is relatively insensitive to E^* and can, therefore, be estimated by extrapolation to energies somewhat below $E = 0.060$ MeV (the lower end of the observed range) with only moderate anxiety. A much greater uncertainty attaches to the extrapolation of the β vs E^* lines for protons. Because of the lack of observational data on protons $E_p < 0.54$ MeV, I have made these extrapolations as shown and find for $\beta = 1$, $E^* = 0.0069$, 0.081, 0.162, and 0.220 MeV for $\gamma = 2$, 3, 4, and 5, respectively. The Walker et al. value of 0.080 MeV for the "characteristic proton energy" (E^* for $\beta = 1$) is the same as my E^* for $\gamma = 3$. If $\frac{dJ}{dE}$ diminishes toward zero by ~ 0.2 MeV rather than increasing to lower energies as E^{-3}, the value of β might well go no higher than ~ 0.15, a significantly high value nonetheless.

B. Number Densities

By Figure 11, the number densities of observed electrons and protons are 2.8×10^{-5} cm^{-3} and 2.5×10^{-5} cm^{-3}, respectively.

For protons with $\gamma = 3$ and $E^* = 0.081$ MeV, the extrapolated number density is 2.8×10^{-3} cm^{-3}. In order to have charge neutrality, assuming the absence of any cool plasma, the extrapolated value of E^* must be 0.0012 MeV for electrons.

C. Position and Structure of the Plasma Sheet

The horizontal dashed lines in Figure 7 mark the time widths and hence the spatial widths of the plasma sheet corresponding to the 1/2 and 1/10 values of the maximum value of $\Delta B^2/8\pi$ as approximated by a smoothed sketch of the peak in the lower panel of Figure 4.

It appears that the spacecraft entered the plasma sheet from the north, just reached or slightly passed its central plane, and then passed out of the sheet back toward the north. Figures 4 and 7, taken together, provide a detailed example of our earlier reports [Van Allen et al., 1974][Goertz, 1976] that the central plane of the dawnside current sheet is accurately in the magnetic equatorial plane and is <u>not</u> warped appreciably (by centrifugal force) toward the mechanical equatorial plane. This fact alone provides a theoretical foundation [Goertz, 1976] for the belief in very hot plasma as the dominant constituent of the plasma sheet. Goertz' recent review [1978] of models of the magnetodisc suggests a characteristic particle energy of tens of kiloelectron volts and a number density of $\sim 10^{-2}$ cm^{-3} at 50 R_J, independently of the work of Walker et al.

One of the striking facts from Figures 4, 5, and 6 is that the structures of the $\Delta B^2/8\pi$ profile and of those for protons $0.54 < E_p < 1.81$ MeV and for electrons $E_e > 0.060$ MeV are similar in detail. For the proton case Walker et al. remark that the "similarity of the particle flux change to the magnetic pressure change implies that the observed protons are closely related to those responsible for the field depression." This qualitative remark appears to be supported by quantitative considerations, at least for protons.

The apparent spatial scale of detailed structure of the proton profile (Figure 5) is $\leq 0.2\ R_J$ even near the apparent center of the plasma sheet where the gyroradius of a 1 MeV proton is of the order of 1 R_J. Detailed structure of this scale is physically impossible for a time-stationary sheet. It appears that the most plausible interpretation is that the plasma sheet is wavering in Z by $\sim 1\ R_J$ on a time scale of a few minutes.

At first sight it is puzzling that the proton profile (Figure 5) is much narrower than the electron $E_e > 5$ MeV profile (Figure 6) despite the fact that the gyroradius of a 5 MeV electron is only one-third as large as that of a 1 MeV proton. A partial and perhaps full explanation lies in the fact that the spectrum of protons falls off much more rapidly with increasing energy than does the spectrum of electrons; hence the effective proton energy is closer to its detector threshold.

The respective profiles in Figure 6 give a detailed example of the earlier report [Baker and Van Allen, 1976] that the electron spectrum in the plasma sheet is softer near its central plane than near its boundaries.

X. CONCLUSIONS

On the whole, it appears reasonable to accept the conclusion of Walker et al. that very hot plasma (characteristic particle energy of ~ 0.1 MeV) is an important and probably dominant contributor to the pressure of the plasma confined by the magnetic field in Jupiter's dawn magnetodisc. The pressure of energetic protons is greater than that of energetic electrons by a factor of the order of ten. It is plausible that charge neutrality exists for the energetic particles at a number density $n \sim 3 \times 10^{-3}$ cm^{-3}. The additional presence of cool plasma is not excluded by present knowledge but an upper limit on its density can be placed on the basis of the relative un-importance of centrifugal pressure.

XI. ACKNOWLEDGMENTS

I am indebted to R. J. Walker for an informal preprint of his April 1978 paper including Figure 5 herein; to C. K. Goertz and M. F. Thomsen, and M. E. Pesses for helpful discussions; and to the Ames Research Center/NASA and the U. S. Office of Naval Research for support of this work.

BIBLIOGRAPHY

BAKER, D. N., and J. A. VAN ALLEN, Energetic Electrons in the Jovian Magnetosphere, J. Geophys. Res., 81, 617-632, 1976.

FILLIUS, R. W., and C. E. McILWAIN, Measurements of the Jovian Radiation Belts, J. Geophys. Res., 79, 3589-3599, 1974.

GOERTZ, C. K., The Current Sheet in Jupiter's Magnetosphere, J. Geophys. Res., 81, 3368-3372, 1976.

GOERTZ, C. K., The Jovian Magnetodisc, University of Iowa Research Report 78-27, May 1978.

McDONALD, F. B., and J. H. TRAINOR, Observations of Energetic Jovian Electrons and Protons, pp. 961-987 of Jupiter, edited by T. Gehrels, University of Arizona Press, Tucson, 1976.

NORTHROP, T. G., C. K. GOERTZ, and M. F. THOMSEN, The Magnetosphere of Jupiter as Observed with Pioneer 10. 2. Nonrigid Rotation of the Magnetodisc, J. Geophys. Res., 79, 3579-3582, 1974.

SIMPSON, J. A., D. C. HAMILTON, R. B. McKIBBEN, A. MOGRO-CAMPERO, K. R. PYLE, and A. J. TUZZOLINO, The Protons and Electrons Trapped in the Jovian Dipole Magnetic Field Region and Their Interaction with Io, J. Geophys. Res., 79, 3522-3544, 1974.

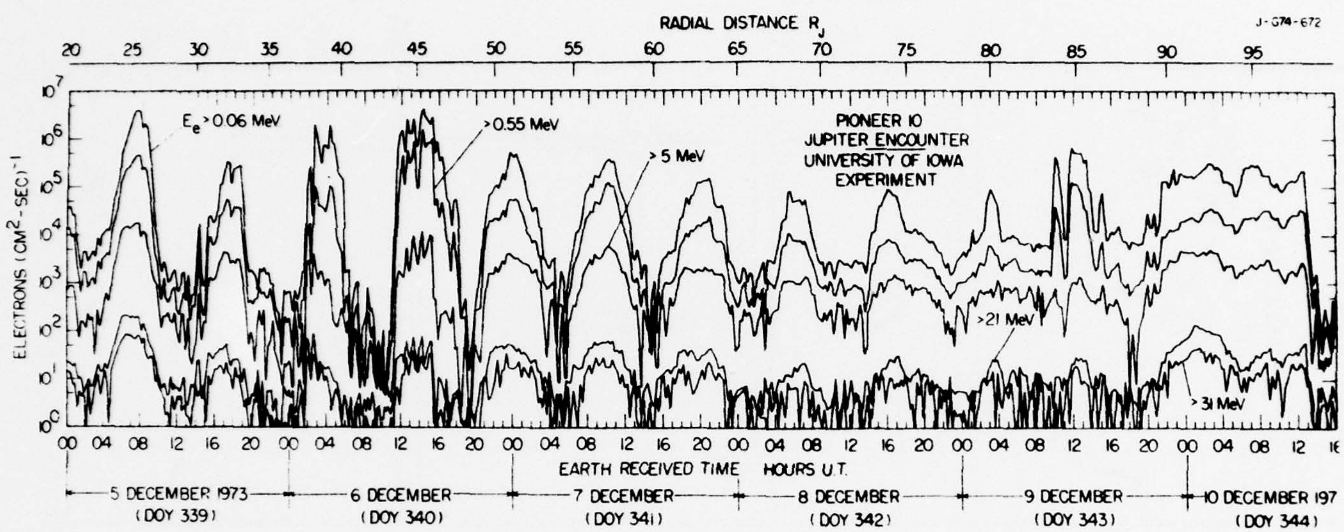
SMITH, E. J., L. DAVIS, JR., D. E. JONES, P. J. COLEMAN, JR., D. S. COLBURN, P. DYAL, C. P. SONETT, and A. M. A. FRANDSEN, The Planetary Magnetic Field and Magnetosphere of Jupiter: Pioneer 10, J. Geophys. Res., 79, 3501-3513, 1974.

TRAINOR, J. H., F. B. McDONALD, B. J. TEEGARDEN, W. R. WEBBER, and E. C. ROELOF, Energetic Particles in the Jovian Magnetosphere, J. Geophys. Res., 79, 3600-3613, 1974.

VAN ALLEN, J. A., D. N. BAKER, B. A. RANDALL, and D. D. SENTMAN, The Magnetosphere of Jupiter as Observed with Pioneer 10. 1. Instrument and Principal Findings, J. Geophys. Res., 79, 3559-3577, 1974.

VAN ALLEN, J. A., High Energy Particles in the Jovian Magnetosphere, pp. 928-960 of Jupiter, edited by T. Gehrels, University of Arizona Press, Tucson, 1976.

WALKER, R. J., M. G. KIVELSON, and A. W. SCHARDT, Evidence for the Dominance of Energetic (> 100 keV) Protons in the Jovian Plasma Sheet, Oral Paper SM-34A, American Geophysical Union, Miami Beach, Florida, 17-21 April 1978.



RADIAL DISTANCE R_J
J-G74-672
ELECTRONS $(CM^2-SEC)^{-1}$
$E_e > 0.06$ MeV
> 0.55 MeV
> 5 MeV
> 21 MeV
> 31 MeV
PIONEER 10
JUPITER ENCOUNTER
UNIVERSITY OF IOWA
EXPERIMENT
EARTH RECEIVED TIME HOURS U.T.
5 DECEMBER 1973 (DOY 339)
6 DECEMBER (DOY 340)
7 DECEMBER (DOY 341)
8 DECEMBER (DOY 342)
9 DECEMBER (DOY 343)
10 DECEMBER 197 (DOY 344)

Figure 1

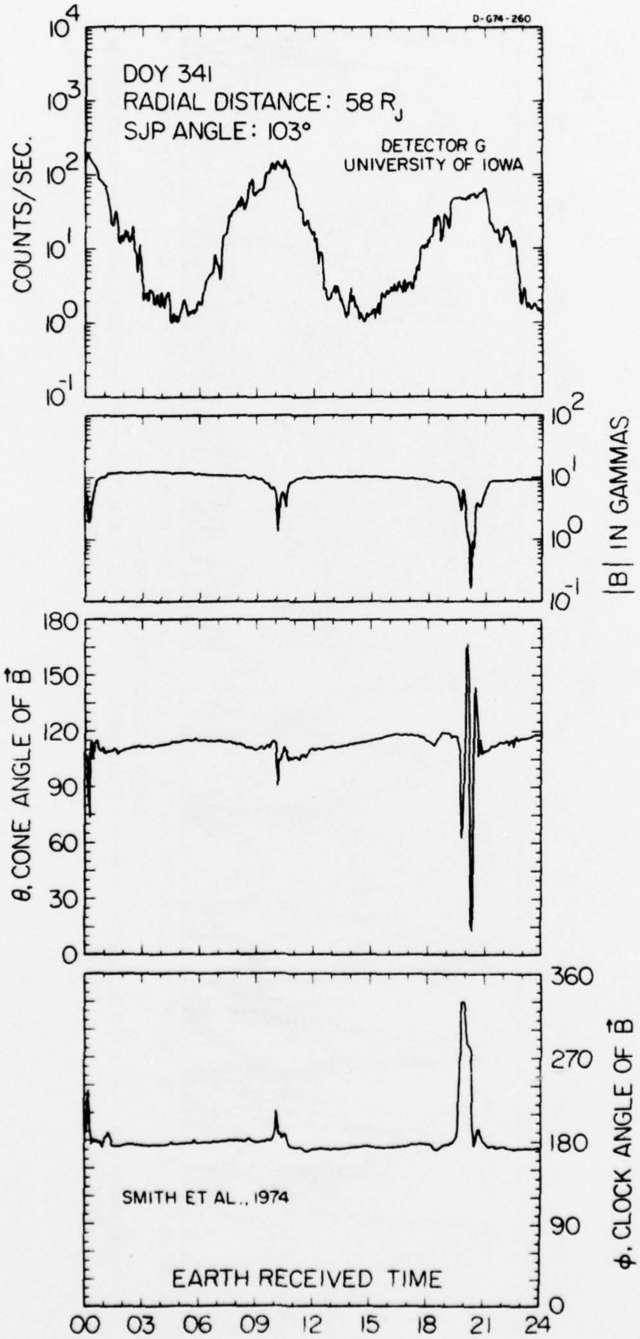

D-G74-260
DOY 341
RADIAL DISTANCE: 58 R_J
SJP ANGLE: 103°
DETECTOR G
UNIVERSITY OF IOWA
COUNTS/SEC.
|B| IN GAMMAS
θ, CONE ANGLE OF $\vec{B}$
φ, CLOCK ANGLE OF $\vec{B}$
SMITH ET AL., 1974
EARTH RECEIVED TIME
00 03 06 09 12 15 18 21 24

Figure 2

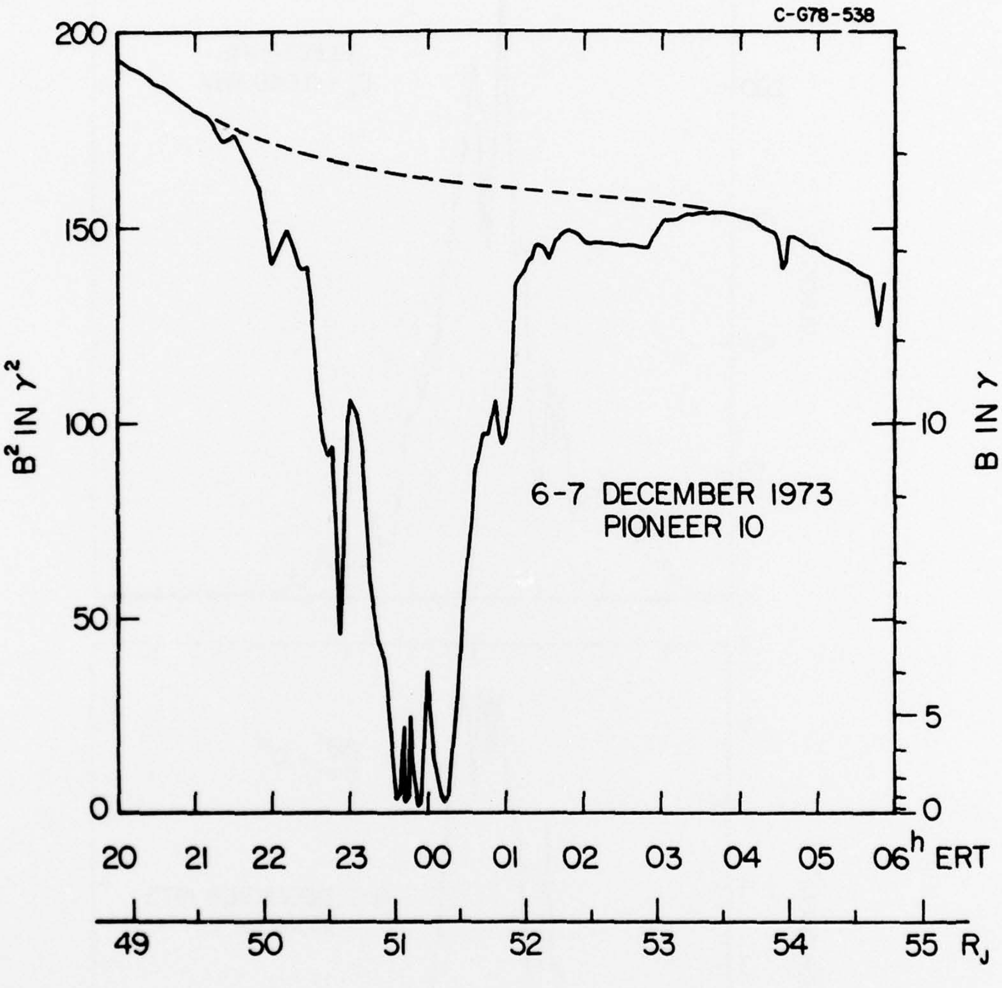
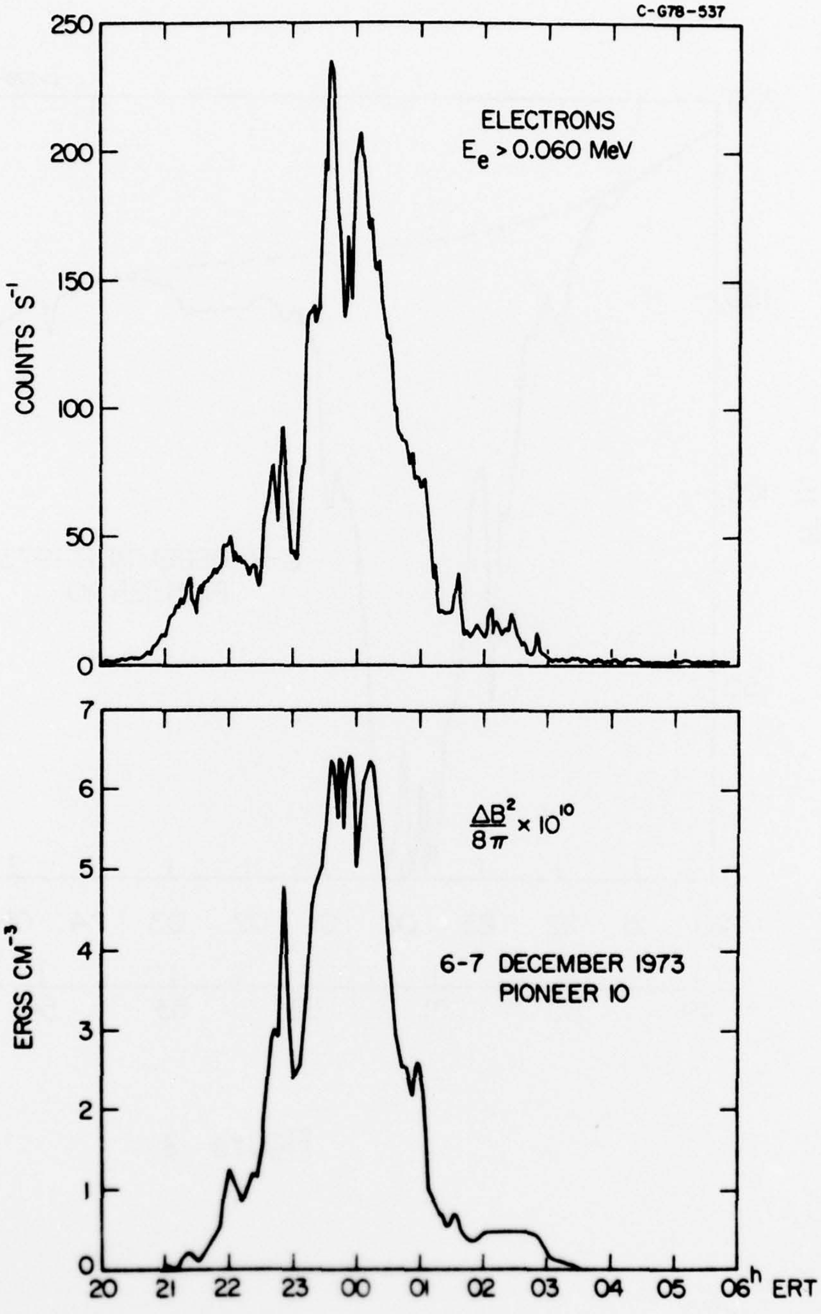

C-G78-538
200
150
100
50
0
B^2 IN γ^2
B IN γ
10
5
0
6-7 DECEMBER 1973
PIONEER 10
20
21
22
23
00
01
02
03
04
05
06^h ERT
49
50
51
52
53
54
55 R_J

Figure 3



C-G78-537
ELECTRONS
$E_e > 0.060$ MeV
COUNTS S^{-1}
250
200
150
100
50
0
7
6
5
4
3
2
1
0
$\frac{\Delta B^2}{8\pi} \times 10^{10}$
ERGS CM^{-3}
6-7 DECEMBER 1973
PIONEER 10
20
21
22
23
00
01
02
03
04
05
06^h ERT

Figure 4

A-G78-544

Walker, Kivelson and Schardt, 1978

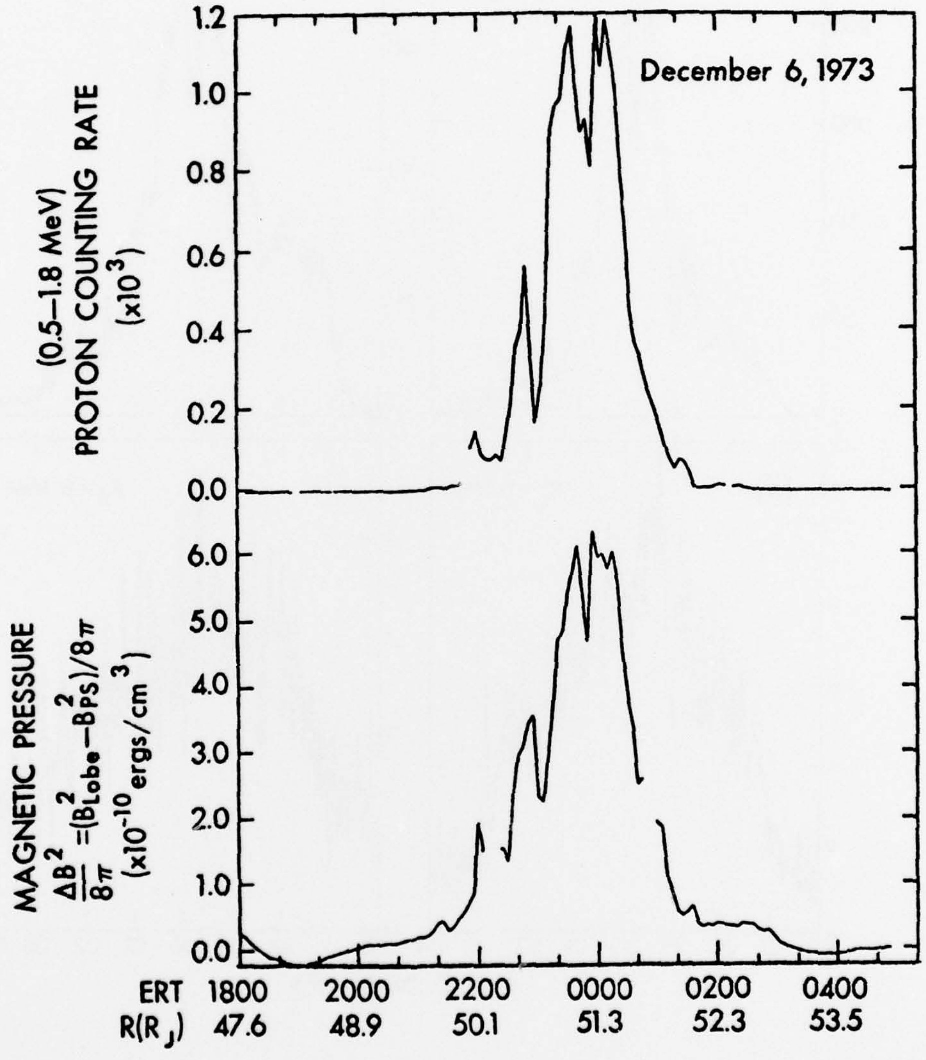


Figure 5

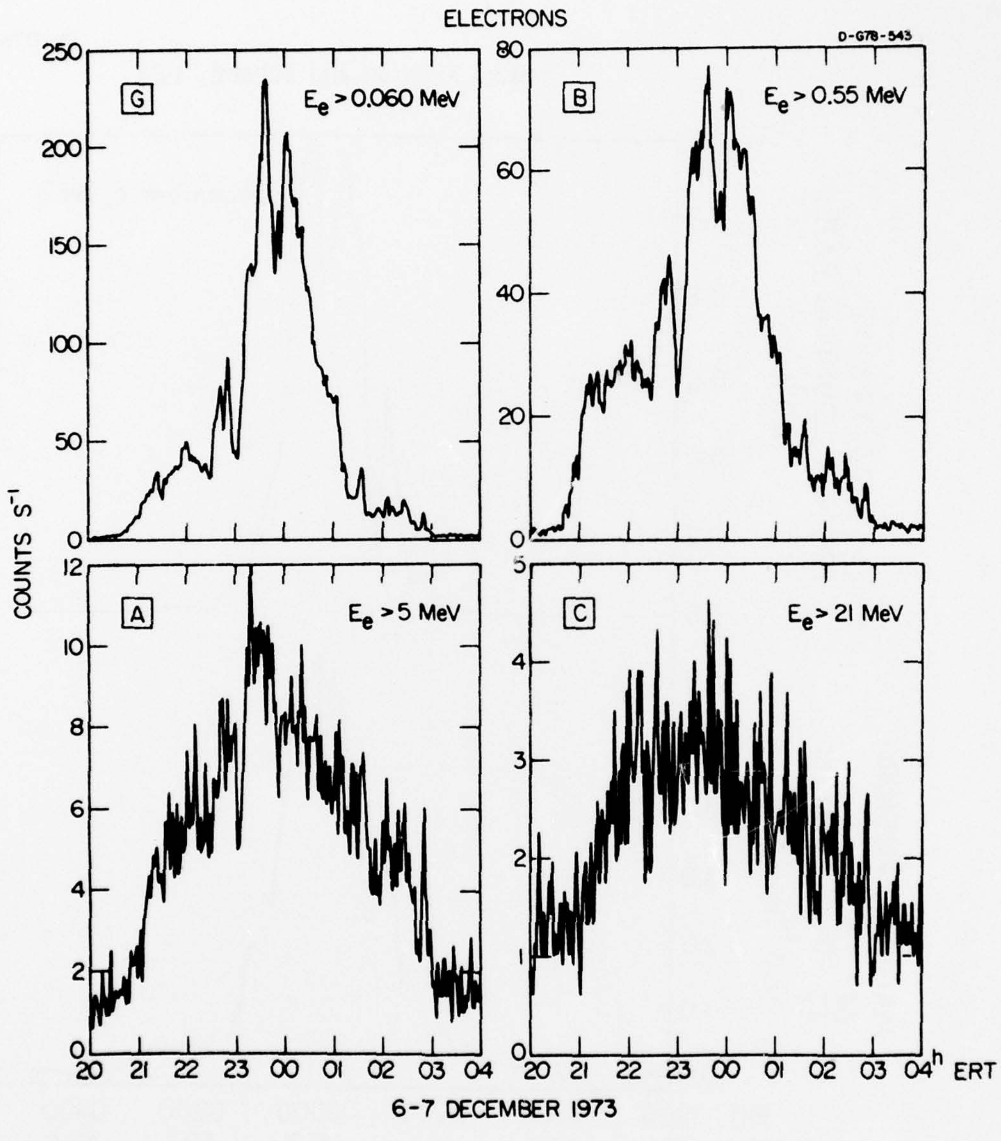

ELECTRONS
D-G78-543
G
$E_e > 0.060$ MeV
B
$E_e > 0.55$ MeV
A
$E_e > 5$ MeV
C
$E_e > 21$ MeV
COUNTS S^{-1}
20 21 22 23 00 01 02 03 04
20 21 22 23 00 01 02 03 04^h ERT
6-7 DECEMBER 1973

Figure 6

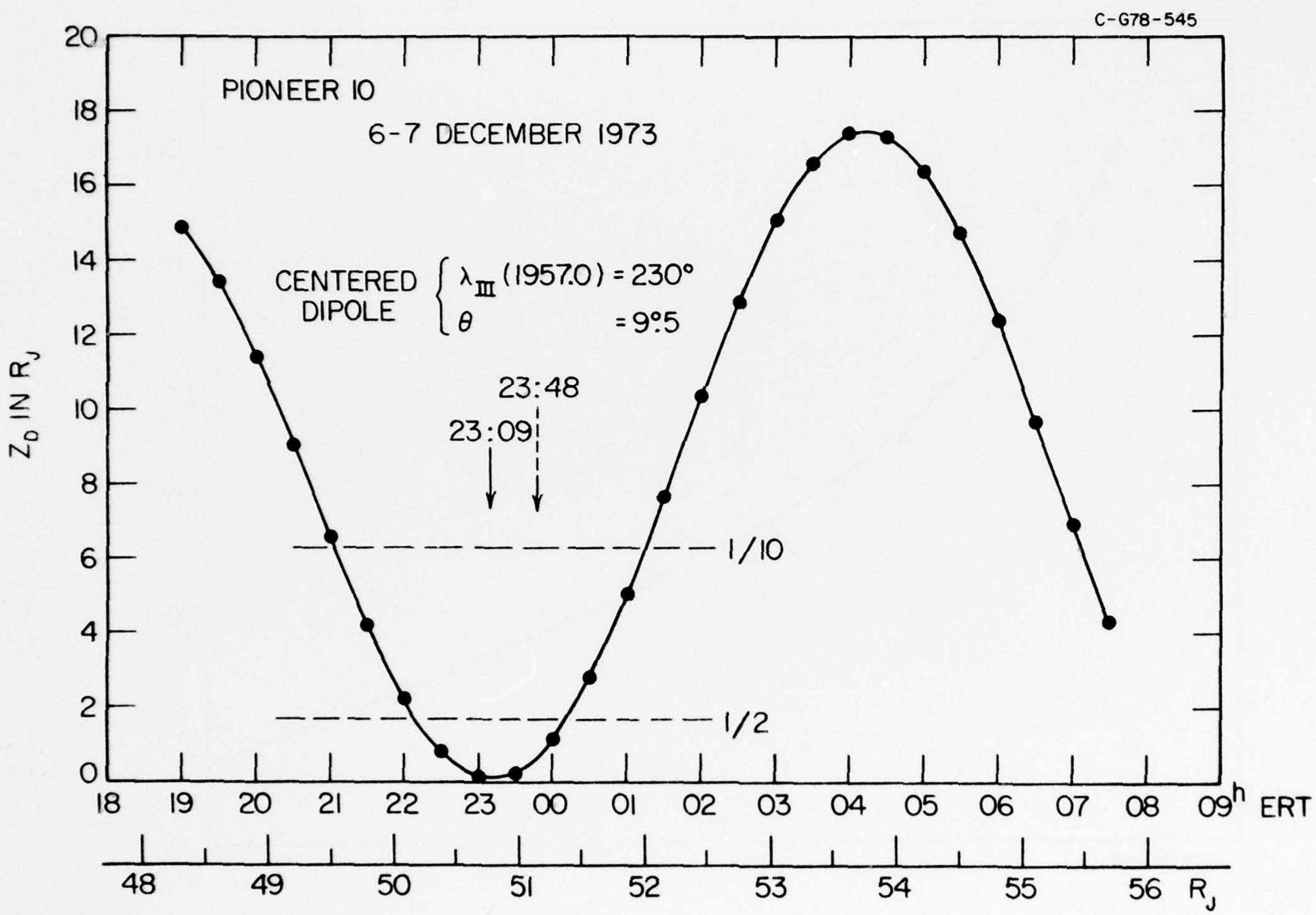

C-G78-545
PIONEER 10
6-7 DECEMBER 1973
CENTERED DIPOLE
λ_{III} (1957.0) = 230°
θ = 9°5
23:48
23:09
1/10
1/2
Z_D IN R_J
0
2
4
6
8
10
12
14
16
18
20
18
19
20
21
22
23
00
01
02
03
04
05
06
07
08
09^h ERT
48
49
50
51
52
53
54
55
56
R_J

Figure 7

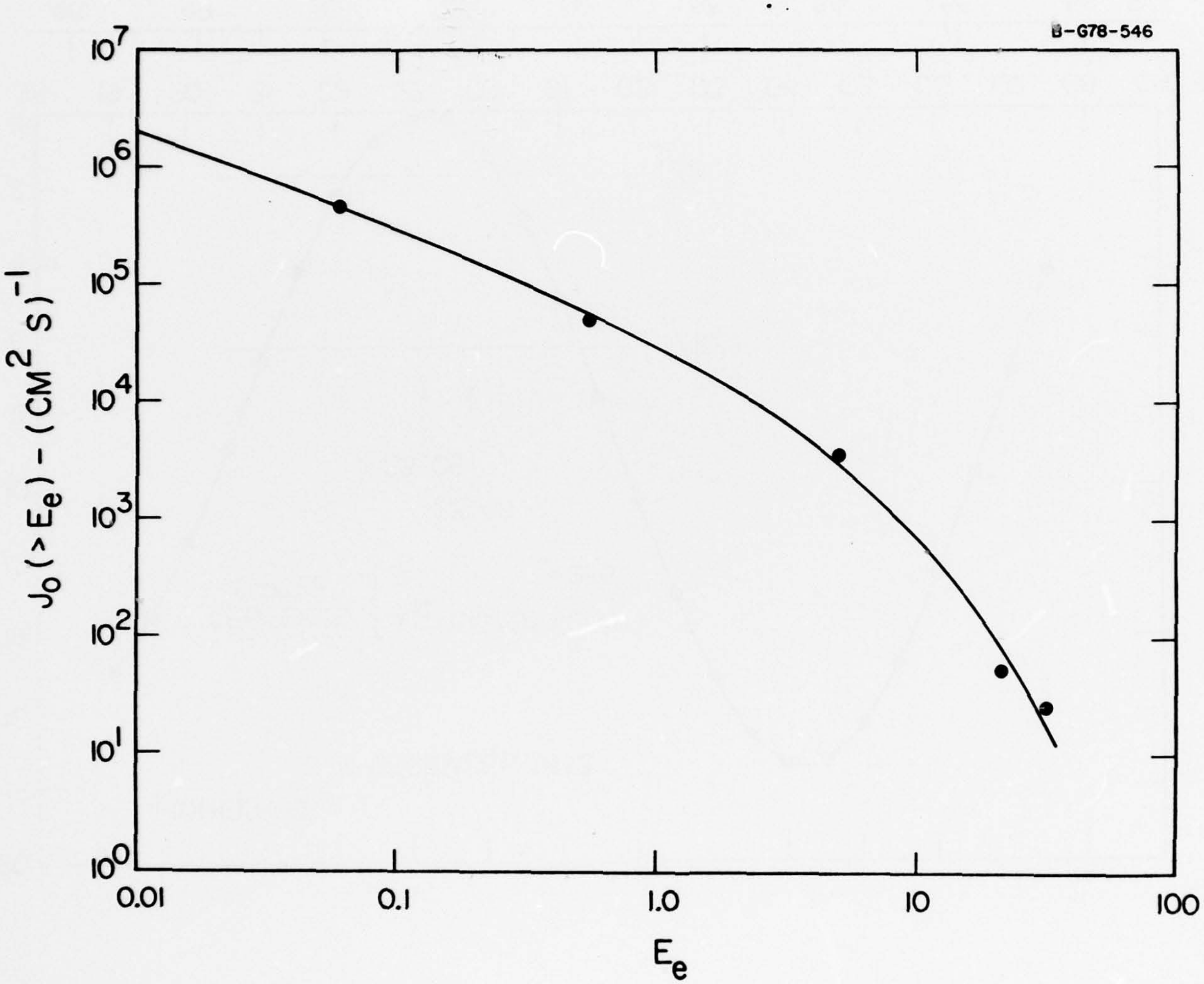

B-G78-546
10^7
10^6
10^5
10^4
10^3
10^2
10^1
10^0
J_o (> E_e) - (CM^2 S)^-1
0.01
0.1
1.0
10
100
E_e

Figure 8

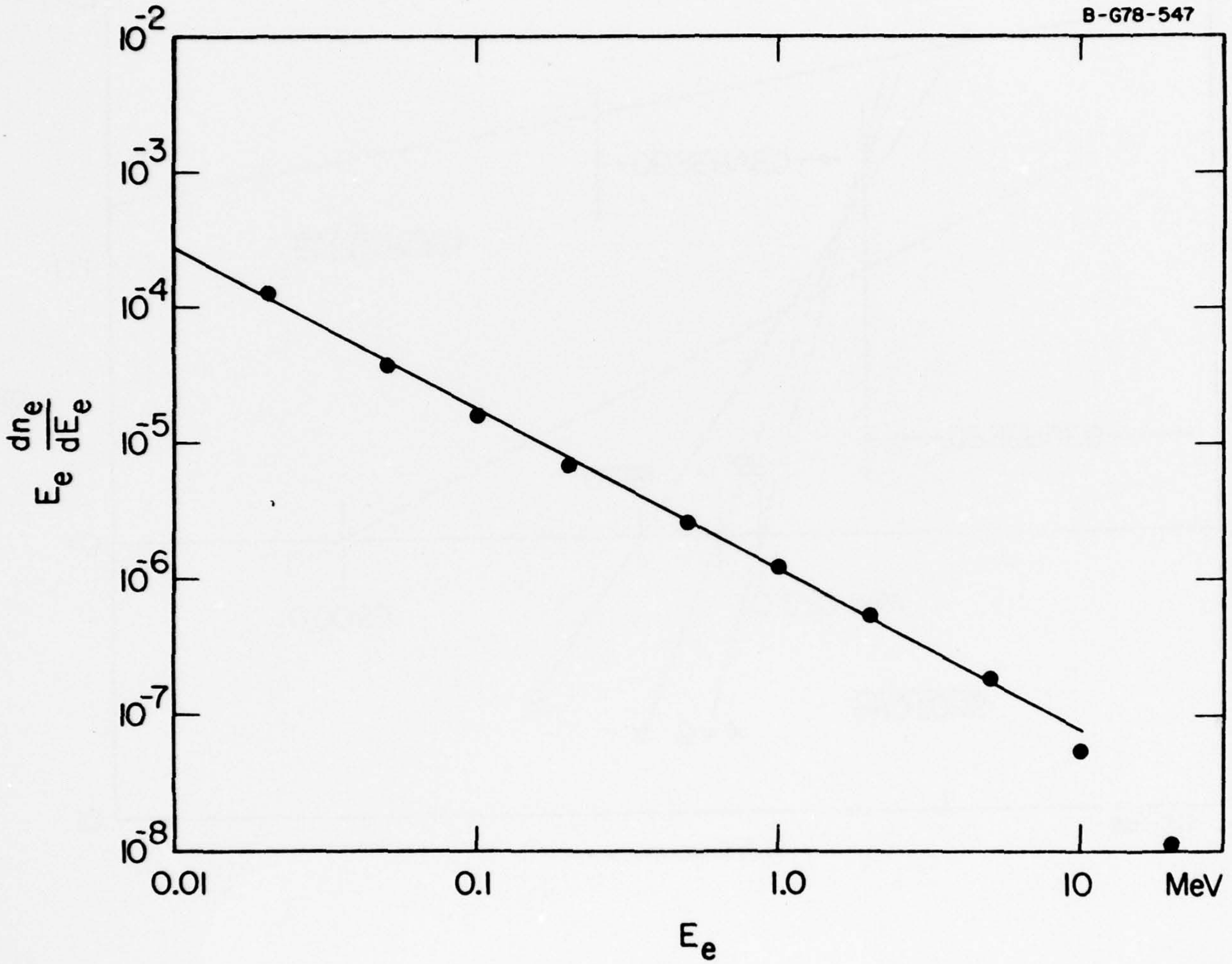
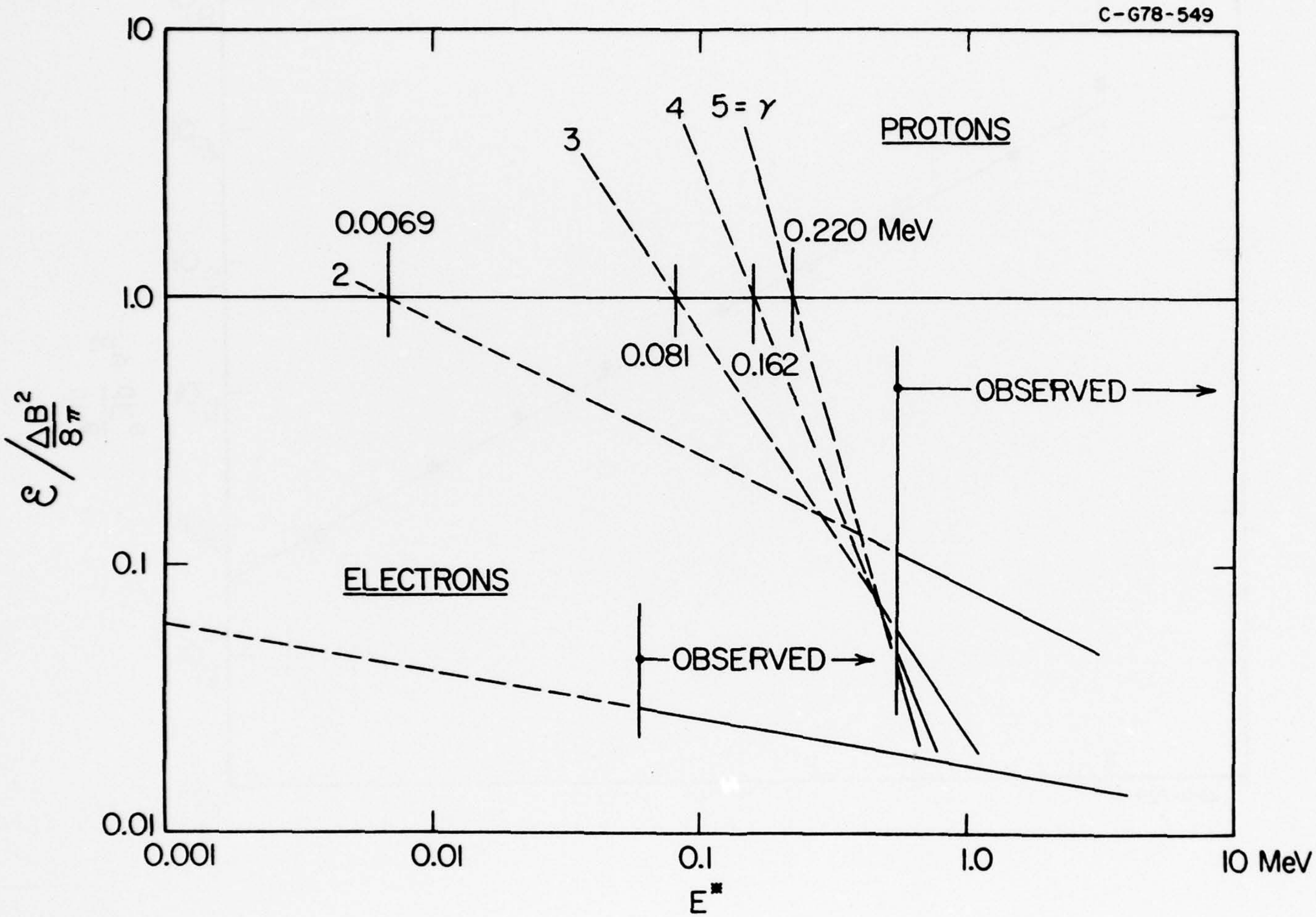

B-G78-547
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
$E_e \frac{dn_e}{dE_e}$
0.01
0.1
1.0
10
MeV
E_e

Figure 9



C-G78-549
10
1.0
0.1
0.01
$\mathcal{E} / \frac{\Delta B^2}{8\pi}$
0.001
0.01
0.1
1.0
10 MeV
E^*
PROTONS
ELECTRONS
2
3
4
5 = γ
0.0069
0.081
0.162
0.220 MeV
OBSERVED
OBSERVED

Figure 10

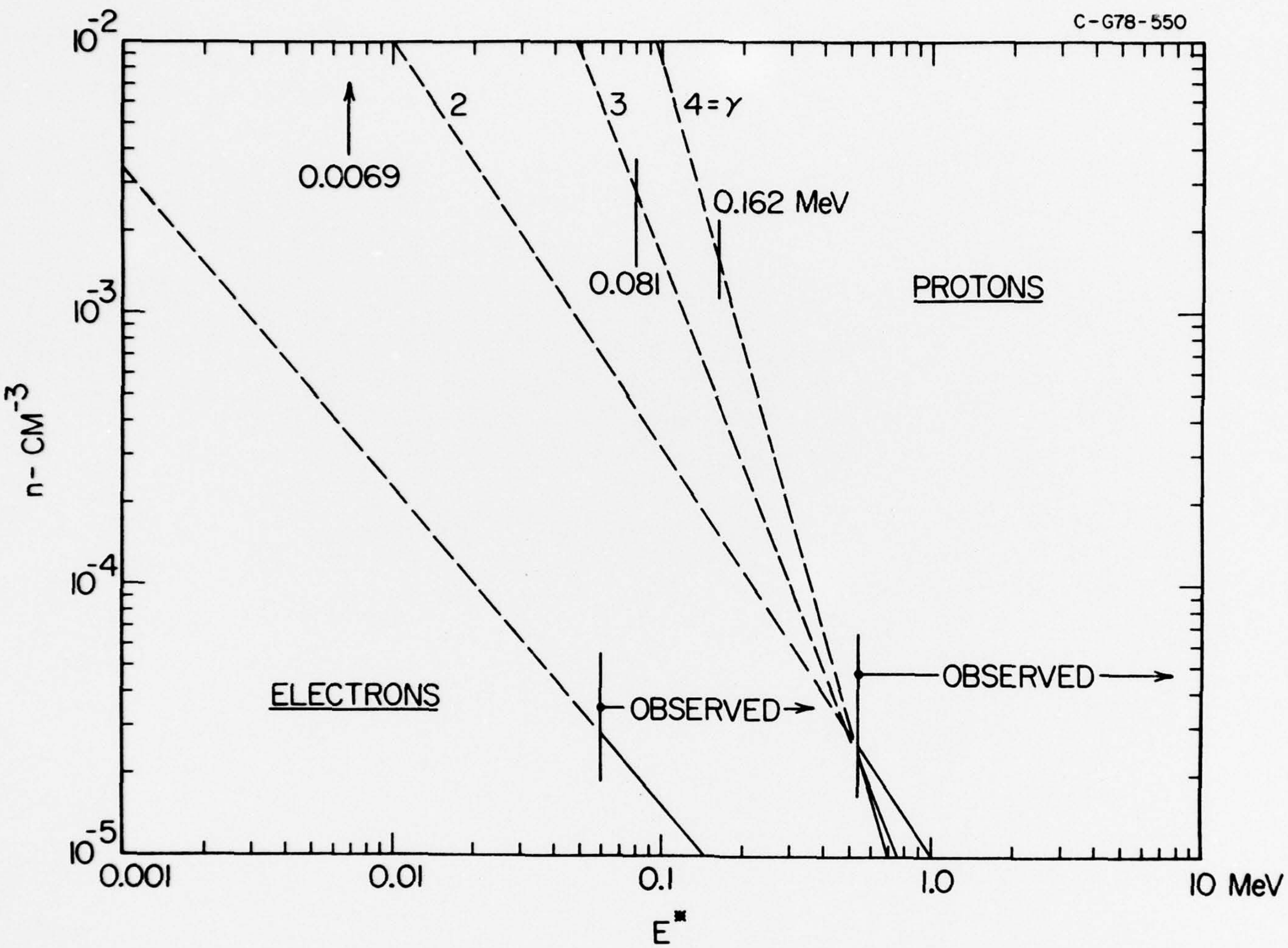

C-G78-550
10^{-2}
10^{-3}
10^{-4}
10^{-5}
n - CM^{-3}
0.001
0.01
0.1
1.0
10 MeV
E^*
2
3
$4=\gamma$
0.0069
0.081
0.162 MeV
PROTONS
ELECTRONS
OBSERVED
OBSERVED

Figure 11